Supply chain process optimisation via the management of variance

Abstract
This paper presents a new optimisation approach for variance within a supply chain management process. The approach is presented by the variance cube of purchasing that involves a lean method for variance optimisation, namely the cost and variance driver analysis. The approach focuses on the optimisation and the control of existing process variance within the supply chain. The application of the cube is presented by a case study involving a globally acting Tier 1 supplier, who produces steering systems for passenger cars and commercial vehicles. In this case, the sourcing process of this Tier 1 supplier will be analysed, evaluated and optimised regarding variance. The variance is presented in form of the number of suppliers who are involved in the sourcing process. Unnecessary existing process variance, like an unnecessary huge number of suppliers within the sourcing process, is a type of waste. Time, money, quality and technology can be saved through a greater understanding of the optimal number of suppliers within a sourcing process. The results of the case study lead to a generalised method to optimise the existing process variance, present cost improvements as well as optimising the key performance indicator to manage the number of suppliers in the sourcing process. The general approach can be used for other company departments like logistics and for different industries other than automotive. The insights of this article support the operative user and the strategic company management in order to reduce and improve unnecessary variance in different sections. The structured analysis of supply chain process variance via the variance cube of purchasing and the key performance indicator "optimal supplier number per sourcing process" are new to company management.
Keywords Sourcing Process, Digital Purchasing**,** Process Standardisation, Variance- and Complexity-Management
Paper type Case Study

1. Introduction

The growing importance of supply chain management has led to an increasing recognition of the strategic position of purchasing (Paulraj *et al.*, 2006; Bozarth *et al.*, 2009) and in parallel the digital revolution on the web/internet had a major impact on the performance of firms' purchasing and supply functions (Gallear *et al.*, 2008). There has been a growing interest in the use of information and communication technologies in purchasing and supply across many industry sectors especially in the automotive branch (Gallear *et al.*, 2008). Internet and web-based technologies such as data clouds provide the basis for improved performance across a range of business functions or processes including purchasing and supply management (Jede and Teuteberg, 2015). Web-based technologies, such as e-mail enabled applications, shared databases and market database analysis as well as extranets are believed to provide effective and efficient ways in which, for example, buyers can rapidly gather information about products and services available from potential suppliers, evaluate and negotiate with preferred suppliers, implement order fulfilment over communications links, and access post-sales services (Archer and Yuan, 2000).
On one side, digital purchasing supports the processes and performance of a company due to a digital global network, data sharing and fast communication (Jede and Teuteberg, 2015). On the other side however, there is a risk to create unnecessary variance and complexity in form of a huge number on suppliers within the sourcing process for example due to the easy and fast digital integration (Susanti *et al.*, 2016). Unnecessary variance and complexity is a kind of waste and a disadvantage regarding competitiveness (Liker, 2004).

In this research, a case study from a Tier 1 supplier is presented which analyses this conflict and raises the following question:

RQ1. What is the optimal number on supplier within the sourcing process to achieve the highest level of competitiveness without waste?

To answer this question, the digital sourcing process of this Tier 1 supplier will be analysed, the risk of variance will be evaluated and the process itself will be improved through a new tool, the variance cube of purchasing, abbreviated VCP (Nabhani *et al.*, 2015). The VCP has three dimensions: process, supplier and product. This work describes the general function of the cube and in detail the dimension "process" on the example of the digital sourcing process. The digitisation level of the Tier 1 supplier within the sourcing process is very high due to the fact that six out of ten process steps are digital. A detailed explanation of the process steps is presented in section 4, results. The following section describes the growing importance of the digitisation of the sourcing process and the associated management of complexity and variance.

2. Theoretical background

The supply chain survey of SCM World from 2016 comprising opinions of 1,415 practitioners from different branches around the world. The result shows that the digital supply chain is on the most disruptive and important technologies to be agile (O'Marah, 2016). An agile supply chain strategy is defined through flexibility by adapting quickly, effectively to rapidly changing customer needs (Krieg, 2004) and a cost optimisation approach across the procurement chain (Huang *et al.*, 2002; Christopher and Towill, 2000; Droege, 1999). One important approach of cost optimisation across the procurement chain is the elimination of waste in form of a reduction of unnecessary process variance (Susanti, 2016; Liker, 2004) for example in form of an unnecessary huge number of suppliers within a sourcing process.

2.1 Digital Purchasing

E-Sourcing software is one tool of a digital supply chain technology that has become an integral part of electronic commerce which is shown that electronic auctions and requests for quotes play a central role in the sourcing operations of companies today (Limberakis, 2012). Much research in electronic commerce focuses on the electronic sourcing markets (Amelinckx *et al.*, 2008) and the design of procurement auction formats and bid evaluation algorithms (Huang *et al.*, 2011). The sourcing process of the Tier 1 supplier is a business process, which is also partially supported by an E-sourcing software. The sourcing process is therefore divided in digital process steps, which are based on this individual software and on manual process steps like a personal technical supplier discussion (Kuo *et al.*, 2012). This mix of digital and manual process steps is a challenge for managing variance. In the case of the Tier 1 supplier, the number of suppliers can rapidly increase at the beginning of the sourcing process, since the supply inquiry and collection are 100% automated and digitised.

The insight from Strnadl (2006) and Melao and Pidd (2000) help to come closer to this challenge. A business process is a complete, dynamically coordinated set of activities or logically related tasks that must be performed to deliver value to customers or to fulfill other strategic goals (Strnadl, 2006; Tan *et al.*, 2010; Wang *et al.*, 2007). Melao and Pidd (2000) focus exclusively in business processes and their modeling. They adopt four different perspectives for understanding the nature of business processes. The second perspective describes business processes as complex dynamic systems. The approach of this work is based on this second perspective to consider a business process as a dynamic complex system. The insights of this article will show that the thinking in dynamic complex systems will be helpful to approach the problem of variance formation in the sourcing process through an unnecessary high number of suppliers.

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2.2 Complexity Management

The concept of complexity can be described concerning the characteristics of variety, connectivity and dynamics. The variety includes the number and the type of elements in a system. The term ‘connectivity’ represents the number and the type of the relation between the individual system elements and the dynamics describes the indeterminacy and unpredictability of complex systems (Klabunde, 2003).

The purchasing integrates more and more into the strategic corporate management (Krumm and Schopf, 2014) and strategic management means the control of complex systems, in which the complexity increases with the variety of distinguishable states within the system (Malik, 2008). The goal is an end-to-end focus on integration of business processes throughout the value chain for the purpose of providing optimum value to the end-customer (Green *et al.*, 2008). The degree of complexity depends on the number of system elements, the variety of the relations between these elements and the number of possible system states (Ulrich and Probst, 1995). Real systems can have many different states and the complexity of a system can be quantified and measured with the help of the concept of variety (Rock *et al.*, 2015). Variety is the number of distinguishable states of a system or the number of distinguishable elements of a set (Malik, 2008). Malik (2008) clarifies that a supposed simple system can have enormous variety and the complexity of a system can be kept under control only by an equally complex system. The British cybernetics, Ashby (1956), has formulated this insight as follows: “Only variety can absorb variety”.

2.3 Internal and external complexity

Schuh (2005) divides the term complexity into internal and external complexity. External complexity occurs in the environment of a company through customer requirements and market changes for example, whereas internal complexity can occur through product and process-diversity within the company (Stjepandić *et al.*, 2015). Today companies are exposed daily to internal and external complexity. The internal complexity especially must be identified and controlled and possible potentials noted. The avoidance of unnecessary variety is a key element for a company to be successful and competitive (Rapp, 2010). A company should not produce unnecessary variety, which is unnoticed on the market side. For a company, variety is considered wasteful when it is without customer value. Within Lean Management, this is known as "Muda", which is a process or activity of not adding value to a product for the customer (Liker, 2004).

For Malik (2008), the key element to quantify and to measure the complexity of a system is with the help of the concept of variance management. In this coherence, the variance must also be differentiated into external and internal variance, like the complexity is. The external variance is useful for the customer in the form of variety of the product variants. The internal variance describes, in the context of order processing, the variety of products and processes that are necessary for the performance of the external variance (ElMaraghy *et al.*, 2013). The misunderstanding of the customer orientation leads to an expansion in variant figures and strong economic problems for a company connected with a loss of competitiveness (Boutellier *et al.*, 1997).

Three general approaches of variance-optimisation are described in numerous publications by different authors:

1) The avoidance of variance, 2) the reduction of variance and 3) the control of variance (Bayer, 2010; Scheer *et al.*, 2006; Grotkamp and Franke, 2007).

The second and the third approach of variance-optimisation regarding the internal company complexity are the center of attention in the present study. This article describes a solution for the problem of the increasing

complexity by variance and presents a solution by connecting the areas of purchasing, lean management and complexity- and variance-management.

3. Methodology

3.1 Variance Cube of Purchasing (VCP)

It is proclaimed that each year, the Original Equipment Manufacturer (OEM) aims for cost savings from the suppliers without a loss of performance on quality and logistics. The pressure of the OEM runs throughout the complete supply chain (Wei, 2008). Due to these facts originate the findings, which have led to the development of the VCP, from a Tier 1 automotive steering system with a very high proportion of bought-in parts. The influence of the purchasing on the overall result of the company is therefore immense (Schiele, 2007).

Considering the variance management for the product, process and market views (ElMaraghy *et al.*, 2013) and internal and external dimensions of purchasing practices (Day and Lichtenstein, 2006), the variance cube of purchasing is formed from three dimensions: product, supplier and process. The dimensions represent the workspaces of the purchasing department in a company (Paulraj *et al.*, 2006). The core business in the purchasing department is to buy products from suppliers according to the defined company processes (Rast, 2008). From the view of purchasing, especially from a commodity group, there are three perspectives to explore: the process perspective, the product perspective and the supplier perspective (ElMaraghy *et al.*, 2013). The product and the process perspective reflect the internal company's structure from the view of purchasing and the supplier perspective represents the environment of a commodity group for example (Schuh, 2005; Marti, 2007). The main interest of the company is to satisfy the customer's needs (Price *et al.*, 2015). The customer's needs, requirements and desires enter the company, which will be virtually filtered, adapted or extended and distributed via the communication interface such as logistics, quality, purchasing, etc. to the supplier.

The Tier 1 supplier has been producing steering systems for many years. In the last 15 years, there was a technical change from a hydraulic steering gear to an electrical steering gear. Currently, both systems are running in parallel but the hydraulic business is declining and the electrical business is expanding. Some processes are based on the old system and some processes were implemented to support the new system. Some components could be used for both systems, but some are unique. Consequently, the number of products, processes and suppliers is very large with the consequence of high internal existing variance and complexity.

According to the presented literature and the fact that purchasing occupies a key role, the requirements for the VCP could be recommended as:

- An efficient localisation of cost potentials in every dimension
- Easy, self-explanatory tools and methods
- A fast increase of cost savings for a company
- A definite localisation and optimisation process of existing internal variance
- A fast development of lean processes
- A pragmatic guideline for the user to find potential cost savings
- An easy adaptability to other departments and industries as e.g. VCL – **V**ariance **C**ube of **L**ogistics

3.2 Dimensions of the VCP- Process Dimension

The focus of this article is on a detailed explanation of the process dimension. Many purchasing processes are installed but not standardised regarding variance. Some examples are the sourcing process, the inquiry process, the contracting process or the strategy process (Gelderman *et al.*, 2015). The Tier 1 supplier has currently no variance-standard for the digital sourcing process. Respectively, the number of the requested suppliers and the technical meetings are not defined in a standard way. The company loses a lot of time and money due to the different handlings of every buyer. Section 4 presents a case study of the digital sourcing process of the Tier 1 supplier. Through the usage of the VCP, especially the process dimension, the current situation can be critically scrutinised and some best practices, optimisation potentials, lean concepts and standards can be presented with the target of increasing efficiency.

3.3 Function of the VCP exemplary for the dimension process

The VCP is a guiding analysis tool for the management or the operating buyer to identify optimisation potentials regarding unnecessary variance. The cube is connected with the company's data base, which performs evaluations or filters in the background. This database is controlled by the selection of certain filter criteria set by the user. The users are guided as a feedback of the database to special processes, which they want to analyse (see figure 1). The first step is constructed as a 3-D-selection and the following steps as a 2-D-selection.

1st Step: The cube is a 3-D-tool and is able to rotate so that the users can select between the perspectives process, supplier and product. The process and product dimensions reflect the internal perspective and supplier dimension represent the external perspective.

2nd Step: The cube switches to a 2-D-matrix with different selection fields. In this case there are three different selection fields: the direct and indirect purchasing and the purchasing quality related to the general structure of the purchasing organisation of the Tier 1 supplier. The cube functions as a guide depending of the needs of the users. There are several selection options like responsibility, highest number of processes, employees or highest personal costs for example. Users have two options to work with the cube: 1) Choose a selection criteria such as "highest number of processes" and the cube highlights automatically the section with the highest number of internal company processes. 2) Users have a detailed responsibility regarding a process and they want to analyse their work area. The users can directly select responsibility and choose their name and the cube will then lead them directly to their responsibility. This option exists also for steps 3 and 4. In this case, the users have selected the highest number on processes and the cube leads them to the section of 'direct purchasing'.

3rd Step: The VCP divides processes, based on the management model of the university St. Gallen, in business, management and support processes (Bleicher, 2011). In this case of the example from figure 1, users select the criterion of the "highest number of process participants" and the cube highlights the field business process.

4th Step: The fourth step is the last selection step and presents processes which will be applied within the Tier 1 supplier. Users will be guided to a special process or they have the choice to select one. Users may choose the selection criterion of the "highest process costs" and the cube will lead them to the process with the highest costs like the sourcing process in this case.

5th Step: The final step is different from the others in terms of switching from selection criteria and rules to methods. E.g. the effort vs. benefit comparison or the cost- and variance-driver analysis. Users are guided through the selection criteria to a particular process, which is now to be examined with a focus on variance. Therefore, users need certain support techniques. The application of these techniques is described in the following case study.

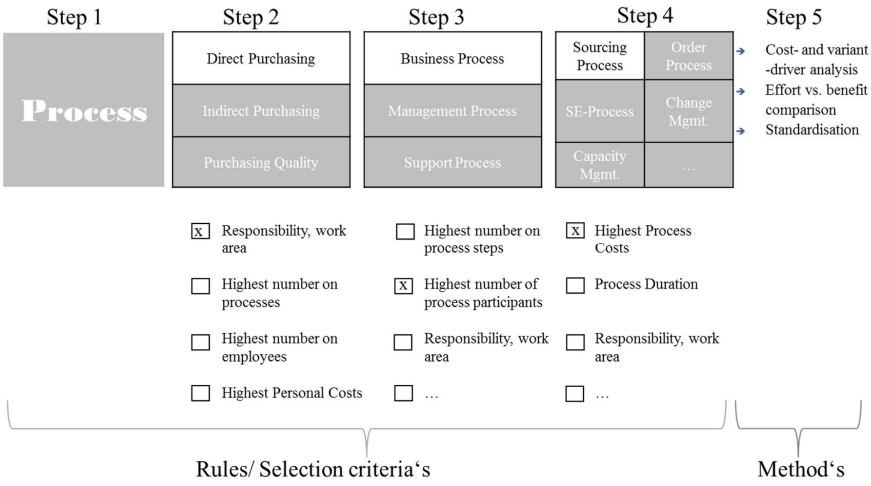

Figure 1: The five steps of the dimension process from VCP

4. Case study

4.1 Research design

This research examines existing structures and data in a company and creates solutions to optimise these structures. (Verschuren and Doorewaard, 2010; Campos *et al.*, 2017). The research is practically orientated, and refers to the unstructured set of problems of which a practitioner must deal with (Dul and Hak, 2008). The practitioner in this case is a buyer of a Tier 1 supplier as a global acting company, which delivers steering systems for passenger cars and commercial vehicles to well-known OEM's worldwide. The empirical research work is supported by an explanatory single case study of research question, data collection, data analysis and the deriving of research findings in form of a new method (Yin, 2003). The research questioning (*RQ1*) have already been formulated in the section introduction. As a reference, Pohl and Förstl (2011) have been successfully in their case study, which analyses a purchasing-variance measurement system for the analysis of a general purchasing performance measurement system.

4.2 Data collection

The collected and evaluated data of the case study represents decades of the Tier 1 supplier history. The Tier 1 supplier produces three different types of car steering systems for different car sizes in Asia, Europe and America and the data is taken from this global database. The assembled steering systems consist of approximately 100 different single components and approximately 90% are purchased parts. Each steering system is individually adapted for the respective customer. The sourcing processes of 50 different single components from 12 different commodity groups such as electronics, casted parts, turned parts etc. of a steering system were analysed and evaluated.

4.3 Data analysis

Business process management is often broken into the two main components ''process control'' and ''process improvement'' whereas the latter makes fundamental changes to processes to achieve higher performance levels. In order to support the improvement of processes, methodologies, techniques and tools were developed (Snee and Hoerl, 2003; Duan and Xiong, 2015). One technique is the development of a business improvement strategy that aims to improve the effectiveness and efficiency of all those operations (or processes) that deal with customer needs and expectations (Antony and Banuelas, 2002). It is a continuous improvement strategy for (business) processes (Banuelas and Antony, 2003) and a supportive method for the improvement part of business process management.

The data in this research was examined with the help of a cost- and variant-driver analysis (Atashgar *et al.*, 2017; Duan *et al.*, 2017). This kind of analysis is structured into five different phases. The five phases of define, measure, analyse, improve and control (DMAIC) will be used as a reactive method to find the root causes for the number of variants and the optimum solution (Alvarez, 2015).

4.4 Test of the VCP-process dimension for the sourcing process

The 5 phases (define, measure, analyse, improve and control) of the cost- and variance-driver analysis will be explained and practiced within the following case study of the sourcing process for a single component.

Phase 1: Define and visualise the single steps of the digital sourcing process

Figure 2 and the corresponding table 1 show the different process steps of the sourcing process of the Tier 1 supplier and the corresponding explanation.

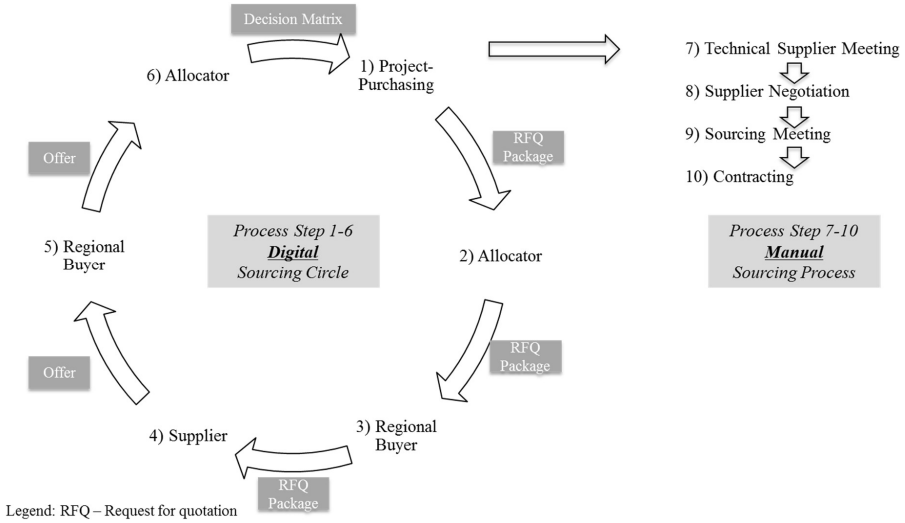

Figure 2: The sourcing process

Table 1: Explanation of the sourcing process steps

Process-Steps	Explanation	Digital/ Manual
1) Project Purchasing	The project buyer creates a RFQ-package with the following content: project data, drawings, specifications, norms etc.	digital
2) Allocator	The allocator analyses the RFQ-package regarding the component, material, regions, demands, complexity etc. and finally defines the potential suppliers which should receive the request.	digital
3) Regional Buyer (RB)	Every regional buyer has the mandate for special suppliers. The RB receives the RFQ based on the pre selection of the potential suppliers from the allocator. After a short analysis regarding volume, target price etc. the RB sends out the RFQ to the suppliers.	digital
4) Supplier	The supplier evaluates the RFQ, prepares an offer and sends the offer back to regional buyer.	digital
5) Regional Buyer	The regional buyer analyses the offer regarding completeness and forwards the offer to the allocator.	digital
6) Allocator	The allocator summarises all offers and creates an offer comparison via e.g. a decision matrix with different commercial, technical and strategic criteria.	digital
7) Technical Supplier Meeting (TSM)	The technical supplier meeting is a personal meeting with the suppliers at the production plant of the customer to discuss all relevant technical issues. One person from the following departments will participate: Supplier Quality, Project Purchasing, Commodity purchasing, R&D, Production and the supplier itself with normally one representative as counterpart from every listed department.	manual

8) Supplier Negotiation	The supplier negotiation is a commercial negotiation between the regional buyer (mandate of the supplier) and the supplier. This will be done with every supplier after all technical questions out of the TSM are answered.	manual
9) Sourcing Meeting	The sourcing meeting is an internal management meeting to make the final decision which supplier will be nominated. The project buyer presents the result of the decision matrix and the purchasing management will give the "go" to nominate the selected supplier.	manual
10) Contracting	The contracting will be done between the regional buyer and the nominated supplier.	manual

The whole sourcing process can be divided in digital and manual steps. Process steps 1 to 6 are online steps which means that every participant is doing his tasks through the help of an online platform via the computer. For the manual process steps 7 to 10, personal meetings are necessary which are connected with special efforts like travel costs, working time, meeting rooms, preparation of meeting minutes etc.

Summary phase 1: The definition and the visualisation of the different process steps help to understand the whole system and to gain a first impression which effort per process step is necessary.

Phase 2: Measure of variance drivers

The variance includes the number and the type of elements in a system (Klabunde, 2003). The sourcing process is a system with different elements in form of process steps. The variance in the sourcing process is shown in the form of the number of technical supplier discussions, negotiations, contracts, offers etc. All of these elements have a coherence to the number of selected suppliers in the sourcing process. The more suppliers that are chosen, the more technical discussion, negotiation, contracts and offer analysis is necessary. The effort of the sourcing process increases with the number of selected suppliers. The core variance driver is in consequence, the supplier. The effort of every other process step depends on the number of suppliers in the sourcing process. Currently no standard is implemented which controls the number of suppliers in the sourcing process. The allocator decides how many suppliers will get the RFQ.

Summary phase 2: The core variance driver in the sourcing process is the supplier. The more suppliers are requested, the more effort in form of technical meetings is necessary. Is this increase of effort in parallel a cost increase for the company?

Phase 3: Analysis of cost and variance driver

The analysis phase contains the collection of data and the representation of the current situation (Yin, 2003). The clear target is to increase the efficiency of the company in form of reduction of waste (Liker, 2004). A data collection and evaluation of the sourcing process of 50 different independent components, which have passed the sourcing process of the Tier 1 supplier, have led to the result of figure 3. This figure shows the average costs in form of working time, travel costs etc. of all participants of the sourcing process per process step. The costs are divided in unique costs and in costs per supplier. The diagram is divided in digital and manual process steps. Steps 1-6 are digital steps and steps 7-10 are manual process steps. The digitisation of the first six steps have led to an easy and fast communication with fixed unique costs independent to the number of suppliers. Certain activities within the whole sourcing process, such as the creation of RFQ containers are unique while others, such as technical supplier discussions are related to the number of suppliers. The costs per supplier for the digital steps 1-6 are very low and it's not really important if the number of requested suppliers is increasing.

Multi-sourcing in contrast to single-sourcing, can sometimes be leveraged to optimise the firm's profit and mitigate the associated risk (Allon and Van Mieghem, 2010). The number of the suppliers which receive a RFQ is often very high due to the easy and fast handling of the digital part of the sourcing process and the insights that supplier competition can optimise the company profit.

Derived by figure 3 is the sum of the effort divided in unique costs 15,800 € and in costs per supplier 48,900 €. Every additional supplier within the sourcing process costs the Tier 1 supplier 48,900 €.

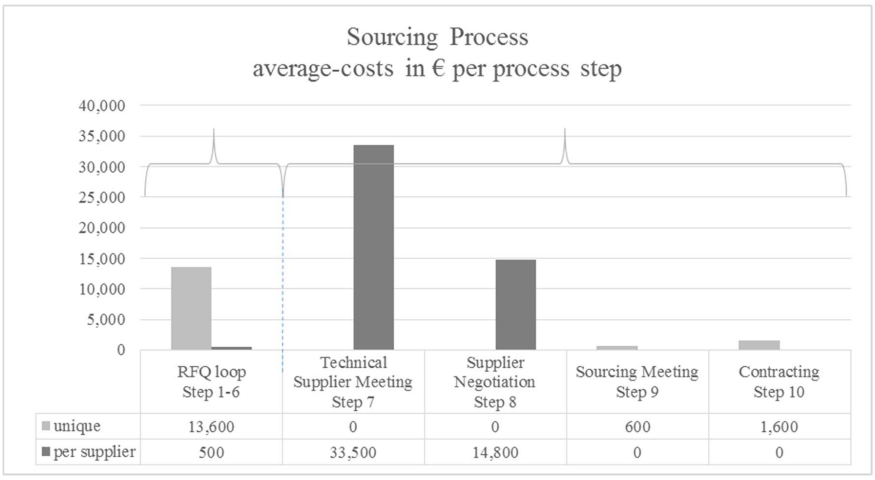

Figure 3: Cost-analysis of sourcing process steps

In comparison, Jiang (2014) shows that simultaneous sourcing as the direct competition for any component will always be better off for the manufacturer regarding costs. An intensive competition analysis of different iterations of the sourcing process for 50 different components at the automotive Tier 1 supplier supports this statement and the results led to the definition of the KPI "supplier step (SST)" and the results in table 2.

Definition KPI: Supplier Step (SST)
The SST is the difference between the number of requested suppliers and the number of winning suppliers. For example in the event of having 7 required suppliers and 5 winning suppliers, the SST will be 2.

Table 2: Savings per Supplier Step

Supplier Step (SST)	0 to **1**	1 to **2**	2 to **3**	3 to **4**	4 to **5**	5 to **6**	6 to **7**
Additional Saving	4,0 %	2,0 %	0,5 %	0,2 %	0,03 %	0,01%	0,01 %
Cumulated additional saving	4,0 %	6,0 %	6,5 %	6,7 %	6,73 %	6,74 %	6,75 %

Table 2 shows a summary of the sourcing results of 50 different components from the Tier 1 supplier. Line one shows the increase of the supplier steps. An increase of the SST means in parallel that an additional supplier was added in the sourcing process. Line two shows the additional savings due to an increase of the supplier competition in percent in relation to the project volume. The higher the SST, the higher the cost savings related to the project volume within the sourcing process are. Line three shows the cumulated savings and the development per SST. The following example shall clearly explain the coherence between SST and cost savings within a RFQ process of a project (table 3).

Table 3 – Project example for coherence between SST and cost saving

Project Name	Alpha
Component	Steering Housing
Volume in € over lifetime	5 M€
Number of winning suppliers	2 suppliers
Number of requested suppliers	7 suppliers

The calculation with a project volume of 5 M€, according to the determined percentage saving values per SST from table 2, results in a decreasing saving cascade per SST which is shown in grey in figure 4. In contrast, figure 4 also shows the increasing cost cascade in black. The costs increase by 48,800 € per SST according to the insights

of figure 3. In this case of a project volume of 5 M€ is the breakeven point between savings and costs on the borderline between SST 2 and SST 3. The implementation of SST 3 means in total five suppliers and that kind of competition generates an additional saving of 25,000 € compared to the previous level of SST 2. In contrast arise costs in the amount of 48,800 € to lead this additional supplier through the sourcing process. The effort is higher than the benefit and the consequence is the creation of waste if the Tier 1 supplier conducts the sourcing process with 7 suppliers. The optimal SST in this case is SST 2. That means 4 suppliers instead of 7.

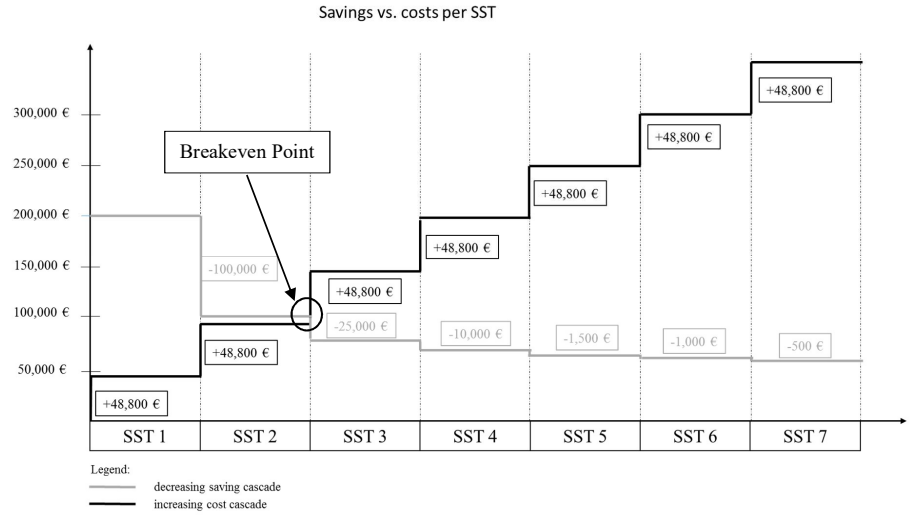

Figure 4: Savings vs. costs per SST

Summary phase 3: The variance driver supplier is in parallel a cost driver, which is shown in figure 3. The costs of the sourcing process increase with 48,800 € per supplier. In parallel is the saving that is due to the possible supplier competition. The breakeven point depends on the project volume. Every project specific breakeven point can be easily determined with these insights regarding costs per supplier in the sourcing process and the saving cascade per SST.

Phase 4: Improvement of the variance structure
The optimal SST can be determined for every project and an unnecessary number of suppliers can be reduced within the sourcing process. In this special case, the optimised variance structure leads to a yearly cost saving, which is shown in the table 4.

Table 4: Initial vs. improved situation

Initial Situation	**Improved Situation**
Number of winning suppliers: 2	Number of winning suppliers: 2
Number of requested suppliers: 7	Number of requested supplier: 4
SST = 7-2 = 5	SST = 4-2 = 2
Costs of SST (5): 5 * 48,800 € = 244,000 €	Costs of SST (2): 2 * 48,800 € = 97,600 €
Cumulated saving of SST (5): -336,500 €	Cumulated saving of SST (2): -300,000 €
Difference between costs and saving: -92,500 €	**Difference between costs and saving: -202,400 €**

The Tier 1 supplier has, in this case study of the sourcing process, for one component with a project volume of 5 M€ over lifetime a total cost improvement of 202,400 € – 92,500 € = **109,900 €.**
This optimisation has positive impacts in form of cost savings within the purchasing department, an increase of the company profit, an increase of the competitiveness and an increase of flexibility within the supply chain and the production (Wei, 2008; Schiele, 2007).

Summary phase 4: This special case with a project volume of 5 M€ for one single component (the steering housing) of the whole steering system has shown a cost improvement of 109,900 € within the souring process. The Tier 1 supplier delivers complete steering systems to the OEM with a huge amount on purchased parts. The case study has shown the potential of one single component of this assembly. The full potential of the VCP approach comes

to play if every purchased part, which is passing the sourcing process is analysed and evaluated according to the shown process steps. Therefore, the fifth and last phase of the cost- and variance-driver analysis is crucial.

Phase 5: Controlling and monitoring
The philosophy of continuous improvement is a basic element of the Toyota Production System (Liker, 2004). The fifth and thus last phase of the methodology is exactly based on this approach. Implemented measures and changes must be controlled at regular intervals and adjusted if necessary. The method is intended to serve as a standard process for variance optimisation. The difficulty in the fifth phase is not to rest but to question optimised things again and initiate appropriate changes.

One helpful key performance indicator (KPI) to measure the development of the variance constantly is the KPI of the "optimal number on **S**uppliers **p**er **S**ourcing **P**rocess", abbreviated SPSP. In the case of the steering housing, the target is a dual source strategy, which means that the number of winning suppliers is two.

General formula of the SPSP KPI:
SPSP = (number of winning suppliers + optimal SST)

Project specific (see table 4):
SPSP = (number of winning suppliers + optimal SST) = 2 + 2 = 4
Rule: The number on requested suppliers in the sourcing process shall be equal to the SPSP.

Summary phase 5: The major challenge of a company is to find the balance between the number of variants and the fulfillment of all customer needs. A company will be successful and competitive in the future, if it meets all customer needs with a minimum variance. The KPI SPSP is helpful to reach this target.

5. Results and discussion
The research findings demonstrate the implementation of a new tool for the structured analysis of existing process variance from the view of the purchasing department, the so-called variance cube of purchasing (VCP). The case study sourcing process covers the process dimension of the VCP. One of the most complex purchasing processes has been used for this case study. The complexity is therefore very high, since the number of participants as well as process steps is very high.
Digitisation, as described in the literature review, is growing more and more in the area of purchasing (Gallear et al., Jede and Teuteberg, 2015). Therefore, to make matters worse, it is also a process that is partially digital and partially manual. However, the complexity is necessary to test the VCP and to be sure that any other purchasing process can be investigated according to this methodology. The insights of the literature review show that digital purchasing supports the processes and performance of a company due to a digital global network, data sharing and fast communication (Jede and Teuteberg, 2015). In comparison, there is a risk to create unnecessary variance and complexity in form of a huge number on suppliers within the sourcing process (Liker, 2004) due to the easy and fast digital integration. This case study has examined precisely this dichotomy by means of a practical example and the result confirms the existence of this risk. This risk is in parallel a potential for improvement to avoid waste within a digital sourcing process. It's currently not covered by researchers in the literature and a new insight. The result from this case study is that each sourcing process has an optimal number of suppliers for the request. This optimal number of suppliers depends on the project volume to be allocated. Previously, it was not possible to determine this optimal number of suppliers. Any additional supplier in the sourcing process, which is actually not needed, is wasteful and costs the Tier 1 supplier 48,800€. Because of this study, it is now possible for the Tier 1 supplier to determine the optimal number of inquiry suppliers for the respective sourcing process. This avoids unnecessary costs for the guidance of an unnecessary supplier through the sourcing process. In this specific case, the savings are 109,000 €. The resulting new KPI 'SPSP' of this case study is a controlling element for the Tier 1 supplier to track for every sourcing process the optimal number of suppliers. Based on these results it is proved that too many suppliers were drawn too long within the sourcing process. It is easy to add suppliers due to the digital process steps at the beginning. However, the number of suppliers must always be correlated with the project volume and the necessary competition. The KPI SPSP ensures exactly this correlation.
From our analysis we can conclude with confidence that the management of existing internal variance from the perspective of purchasing will support the competiveness of a company. We also believe that this study can supplement the literature on the integration of strategic purchasing. In discussing this potential, we have started with the theoretical approach of Bayer (2010), Scheer et al. (2006) and Grotkamp and Franke (2007) that the management of variance can be done through the avoidance, the optimisation and the control of variance. These three approaches of variance management build the basis for different practical methods. Most of the practical approaches involve focusing on the avoidance of variance from the beginning of the product engineering process (PEP). For example, the insights of Adobor and McMullen (2014) and Sjoerdsma and van Weele (2015) cover the avoidance approach through early supplier integration in the PEP. Our analysis focuses on the optimisation approach through the methodical analysis and evaluation of existing internal variance and complexity. The novelty of this research is the variance optimisation focus from the view of the purchasing department. The purchasing department functions as a filter system for existing internal variance and complexity.

The research underlines the argument that the analysis of existing variance through the VCP, the cost and variance-driver analysis and the reporting of the SPSP will save money and supports the competitiveness of a company. A future purchasing strategy will be under the slogan of "lean purchasing through variance optimisation". The VCP supports this slogan and optimises an existing complex and non-transparent process variance structure.

6. Conclusions and directions for further research

The research investigated the current state of supply chain process variance at a Tier 1 supplier of the automotive industry.

From this research the following conclusions may be drawn:

- The variance cube of purchasing (VCP), combined with the method for cost and variance driver analysis, is a new model for the evaluation and optimisation of such an existing process variance.
- The VCP connects elements from the sections lean management, purchasing and variance management. Through this link, a structured analysis of the existing process variance is possible, which leads to saving potentials in the form of costs.
- In the course of the case study, a new KPI has been developed, which is helpful for company management in the control of internal variance.
- The new KPI identifies the optimal number on suppliers per sourcing process

As strategic purchasing is receiving increased attention, firms strive to implement strategic purchasing to its highest potential. The result of this study is expected to help researchers and decision makers to understand the effects of advances in strategic purchasing on variance- and complexity management in a better way. Both managers for reporting and controlling targets and buyers for the daily business can use the methods, tools and approaches to create improvements for the company. The management of the Tier 1 supplier has the possibility to analyse and evaluate the existing process diversity of the company in its entirety with the VCP and its KPI's. The potentials involved in such an analysis are immense and make the company more competitive on the market.
But, the working with the VCP can only be successful if a good data base is available, sub suppliers are open to share information and the employees are well-trained for this method. Another point is that the VCP is a living data base that can only be as good as it is fed. The management has here the task of designing the environment in such a way that every employee has the opportunity to contribute his knowledge and experience. The VCP is a learning element that is to be constantly further developed.
At this juncture, we acknowledge also some limitations of our study that would provide opportunities for further research and improvements of the method. The case studies selected for this research are all within the context of one company and thus in a limited context of industries. This introduces the possibility of context-specific findings. Our research should be replicated in other industries and organisations. The whole supply chain and especially the purchasing department build the centre of the study and show a special perspective. The VCP, the method of cost and variance-driver analysis and the KPI SPSP are new elements and an optimised approach to handle this problem. The insights could be standardised and transferred to other branches and sectors with similar problems.

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